

The Magellanic Squall: Gas Replenishment from the Small to Large Magellanic Cloud

Kenji Bekki^{1*} and Masashi Chiba²

¹*School of Physics, University of New South Wales, Sydney 2052, NSW, Australia*

²*Astronomical Institute, Tohoku University, Sendai, 980-8578, Japan*

Accepted, Received 2005 February 20; in original form

ABSTRACT

We first show that a large amount of metal-poor gas is stripped from the Small Magellanic Cloud (SMC) and fallen into the Large Magellanic Cloud (LMC) during the tidal interaction between the SMC, the LMC, and the Galaxy over the last 2 Gyrs. We propose that this metal-poor gas can closely be associated with the origin of LMC's young and intermediate-age stars and star clusters with distinctively low-metallicities with $[\text{Fe}/\text{H}] < -0.6$. We numerically investigate whether gas initially in the outer part of the SMC's gas disk can be stripped during the LMC-SMC-Galaxy interaction and consequently can pass through the central region ($R < 7.5$ kpc) of the LMC. We find that about 0.7 % and 18 % of the SMC's gas can pass through the central region of the LMC about 1.3 Gyr ago and 0.2 Gyr ago, respectively. The possible mean metallicity of the replenished gas from the SMC to LMC is about $[\text{Fe}/\text{H}] = -0.9$ to -1.0 for the two interacting phases. These results imply that the LMC can temporarily replenish gas supplies through the sporadic accretion and infall of metal-poor gas from the SMC. These furthermore imply that if these gas from the SMC can collide with gas in the LMC to form new stars in the LMC, the metallicities of the stars can be significantly lower than those of stars formed from gas initially within the LMC.

Key words: Magellanic Clouds – galaxies:structure – galaxies:kinematics and dynamics – galaxies:halos – galaxies:star clusters

1 INTRODUCTION

Tidal interaction between the LMC, the SMC, and the Galaxy have long been considered to play vital roles not only in dynamical and chemical evolution of the Magellanic Clouds (MCs) but also in the formation of the Magellanic stream (MS) and bridge (MB) around the Galaxy (e.g., Westerland 1999; Murai & Fujimoto 1981; Bekki & Chiba 2005, B05). Although previous theoretical and numerical studies on the LMC-SMC-Galaxy tidal interaction discussed extensively the origin of dynamical properties of the MB (e.g., Gardiner & Noguchi 1995, G96), they have not yet investigated so extensively the long-term formation histories of field stars and star clusters (SCs) in the MCs. Therefore, long-standing and remarkable problems related to the interplay between the LMC-SMC-Galaxy interaction and the formation histories of stars and SCs remain unsolved (See Bekki et al. 2004a, b for the first attempts to challenge these problems).

One of intriguing and unexplained observations on SCs

in the LMC is that an intermediate-age SC (NGC 1718) with the estimated age of ~ 2 Gyr has a distinctively low metallicity of $[\text{Fe}/\text{H}] = -0.8$ among intermediate-age SCs (Geisler et al. 2003, G03; Grocholski et al. 2006, G06). Santos & Piatti (2004, S04) investigated integrated spectrophotometric properties of old and young SCs and found that several young SCs with ages less than 200 Myr have metallicities smaller than -0.6 . Three examples of these low-metallicity objects including Rolleston et al. (1999, R99) are listed in the Table 1. Given the fact that the stellar metallicity of the present LMC is about -0.3 in $[\text{Fe}/\text{H}]$ (e.g., van den Bergh 2000, v00; Cole et al. 2005), the above examples of low-metallicity, young SCs are intriguing objects. No theoretical attempts however have been made to understand the origin of these intriguing objects in the LMC.

The purpose of this Letter is to show, for the first time, that the observed distinctively low metallicities in intermediate-age and young SCs in the LMC can be possible evidences for accretion and infall of low-metallicity gas onto the LMC from the SMC. Based on dynamical simulations of the LMC-SMC-Galaxy interaction for the last 2.5 Gyr, we investigate whether gas stripped from the SMC as

* E-mail: bekki@phys.unsw.edu.au

Table 1. Examples of distinctively metal-poor stars and SCs for the LMC and the inter-Cloud region close to the LMC.

Object name	Age (Myr)	[Fe/H]	Reference
NGC 1718	2Gyr	-0.80 ± 0.03	G06
NGC 1984	4Myr	-0.90 ± 0.40	S04
DGIK 975	41Myr	-1.06 ± 0.12^a	R99

^a Mean metallicity for C, N, Ma, and Si with respect to the solar abundances.

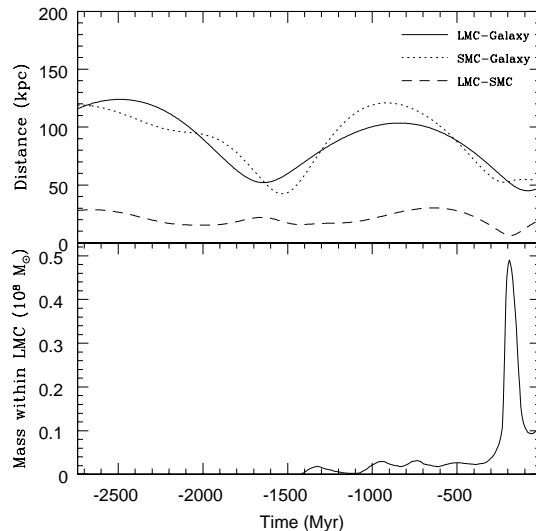
a result of the tidal interaction can pass through the central region of the LMC and consequently can play a role in the star formation history of the LMC. Based on the results of the simulations, we discuss how the sporadic accretion/infall of metal-poor gas onto the LMC from the SMC (referred to as “the Magellanic squal”) can control recent star formation activities of the LMC.

2 MODEL

We adopt numerical methods and techniques of the simulations on the evolution of the MCs used in our previous papers (B05): we first determine the most plausible and realistic orbits of the MCs by using “the backward integration scheme” (for orbital evolution of the MCs) by Murai & Fujimoto (1980) for the last 2.5 Gyr and then investigate the evolution of the MCs using GRAPE systems (Sugimoto et al.1990). The total masses of the LMC (M_{LMC}) and the SMC (M_{SMC}) are set to be $2.0 \times 10^{10} M_{\odot}$ and $3.0 \times 10^9 M_{\odot}$, respectively, in all models. The SMC is represented by a fully self-consistent dynamical model with the total particle number of 200000 whereas the LMC is represented by a point mass. Since we focus on the mass-transfer from the SMC to the LMC, this rather idealized way of representing the LMC is not unreasonable. The gravitational softening length is fixed at 0.1 kpc for all models.

The orbital evolution of the MCs depends strongly on their masses and initial velocities for given initial locations of the MCs (B05). Therefore we first run a large number of *collisionless* models and thereby find models that can successfully reproduce both the MS and its leading arm features. For those models, we investigate time evolution of the SMC’s gas particles that can finally infall onto the LMC. We use the same coordinate system (X, Y, Z) (in units of kpc) as those used in B05. The adopted current positions are $(-1.0, -40.8, -26.8)$ for the LMC and $(13.6, -34.3, -39.8)$ for the SMC and the adopted current Galactocentric radial velocity of the LMC (SMC) is 80 (7) km s^{-1} . Current velocities of the LMC and the SMC in the Galactic (U, V, W) coordinate are assumed to be $(-5, -225, 194)$ and $(40, -185, 171)$ in units of km s^{-1} , respectively. Although the adopted orbits are not so consistent with the observationally suggested proper motion of the MCs by Kallivayalil et al. (2006), we think that the inconsistency may well step from uncertainties of the observational interpretations.

Recent observations on stellar kinematics of old stars in the SMC have suggested that the SMC is *not* a dwarf irregular with a strongly rotating stellar disk but a dwarf spheroidal/elliptical with little rotation (Harris & Zaritsky 2006). The SMC however has been modeled as a low-

**Figure 1.** Time evolution of the distances between the LMC and the Galaxy (solid), the SMC and the Galaxy (dotted), and the LMC and the SMC (dashed), for the last 2.5 Gyrs (upper) and time evolution of the total mass of gas particles that are tidally stripped from the SMC and located within the central 7.5 kpc of the LMC (lower).

luminosity disk system in previous simulations (G96). Considering the above observations, we model the SMC’s stellar component either as a dwarf elliptical (dE) with a spherical shape and no rotation or as a dwarf irregular (dI) with a disk shape and rotation in the present study. The SMC’s stellar (gaseous) component with the size of R_s (R_g) and the mass of M_s (M_g) is embedded by a massive dark matter halo with the total mass of M_{dm} set to be roughly equal to $9M_s$ and the “universal” density distribution (Navarro, Frenk & White 1996). The projected density profile of the stellar component has an exponential profile with the scale length of $0.2R_s$ for the dE and the dI models. R_s is fixed at 1.88 kpc so that almost no stellar streams can be formed along the MS and the MB.

Many dwarfs are observed to have extended HI gas disks (e.g., NGC 6822; de Blok & Walater 2003). The SMC is therefore assumed to have an outer gas disk with an uniform radial distribution, $M_g/M_s (= f_g)$, and $R_g/R_s (= r_g)$ being key parameters that determine the dynamical evolution of the gas. The rotating “gas disk” is represented by *collisionless particles* in the present simulations, firstly because we intend to understand purely tidal effects of the LMC-SMC-Galaxy interaction on the SMC’s evolution and secondly because we compare the present results with previous ones by G96 and Connors et al. (2006) for which the “gas” was represented by collisionless particles. Although we investigate models with different f_g and r_g , we show the results of the models with $f_g = 1$ and 3 and $r_g = 2$ and 4 for which the Magellanic stream with a gas mass of $\sim 10^8 M_{\odot}$ can be reproduced reasonably well. The baryonic mass fraction ($f_b = (M_s + M_g)/M_{\text{SMC}}$) thus changes according to the adopted f_g . Owing to the adopted $r_g = 2$ and 4, a very little amount of stars in the SMC can be transferred into the LMC for the last 2.5 Gyr.

The initial spin of the SMC’s gas disk in a model is specified by two angles, θ and ϕ , where θ is the angle be-

Table 2. Model parameters for the SMC and a brief summary of the results.

Model number	Morphology ^a	f_b ^b	f_g ^c	r_g ^d	θ (degrees)	ϕ (degrees)	$[\text{Fe}/\text{H}]_{\text{acc}}$ ^e	f_{acc} ^f	Comment
1	dE	0.18	1.0	4.0	-30	210	-0.79	0.34	the standard model
2	dE	0.18	1.0	4.0	-45	210	-0.79	0.42	
3	dE	0.18	1.0	4.0	-30	230	-0.78	0.31	
4	dE	0.31	3.0	4.0	-30	210	-0.82	0.47	higher gas fraction
5	dE	0.18	1.0	2.0	-30	210	-0.71	0.65	compact gas disk
6	dI	0.18	1.0	4.0	-30	210	-0.79	0.34	

^a dE and dI denote dwarfs with spherical stellar distributions and irregulars with diskly stellar distributions, respectively.

^b Baryonic mass fraction. $f_b=0.18$ means that the particle masses for dark matter, stars, and gas are $4.9 \times 10^4 M_\odot$, $5.4 \times 10^3 M_\odot$, and $2.7 \times 10^3 M_\odot$, respectively.

^c Gas mass fraction. $f_g=1.0$ means that the gas mass is equal to the stellar mass ($= 2.7 \times 10^8$) in the Model 1.

^d The size ratio of gas disk to stellar one.

^e Mean metallicity of SMC's gas particles that passed through the central 7.5 kpc of the LMC for the last 2.5 Gyr.

^f Mass fraction of all gas particles (of the SMC) that have passed through the central 7.5 kpc of the LMC for the last 2.5 Gyr.

tween the Z -axis and the vector of the angular momentum of the disk and ϕ is the azimuthal angle measured from X -axis to the projection of the angular momentum vector of the disk onto the $X-Y$ plane. Although these θ and ϕ are also considered to be free parameters, models with limited ranges of these parameters can reproduce the MS and the MB (e.g., Connors et al. 2006). The gas disk is assumed to have a *negative* metallicity gradient as the stellar components has (e.g., Piatti et al. 2007). The gradient represented by $[\text{Fe}/\text{H}]_g(R)$ (dex kpc⁻¹) is given as;

$$[\text{Fe}/\text{H}]_g(R) = \alpha \times R + \beta, \quad (1)$$

where R (in units of kpc) is the distance from the center of the SMC, $\alpha = -0.05$, and $\beta = -0.6$. These values of α and β are chosen such that (i) the metallicity of the *central* region of the SMC can be consistent with the observed one ($[\text{Fe}/\text{H}] \sim -0.6$; v00) and (ii) the slope is well within the observed range of α for very late-type, gas-rich galaxies (Zaritsky et al. 1994). If we adopt a stellar gradient (i.e., smaller α) in a model, gas particles stripped from the SMC show a smaller mean metallicity.

We investigate (i) the time (t_{acc}) when gas particles stripped from the SMC pass through the LMC's central 7.5 kpc (corresponding to the disk size with the scale length of 1.5 kpc, v00) and (ii) the metallicities ($[\text{Fe}/\text{H}]$) of the particles' for models with different morphological types (dE or dI), f_b , f_g , r_g , θ , and ϕ in the SMC. Such stripped SMC's particles are referred to as “accreted particles” in the present study just for convenience. We also examine the mean metallicity and the mass fraction of the “accreted particles” ($[\text{Fe}/\text{H}]_{\text{acc}}$ and f_{acc} , respectively) in each of the six models for which values of model parameters are shown in the Table 2. The present simulations with no gas dynamics, no star formation, and a point-mass particle for the LMC can not precisely predict how much fraction of the “accreted particles” can be really accreted onto the LMC's gas disk and consequently used for star formation. We however believe that the present models enables us to grasp essential ingredients of gas transfer between the MCs for the last few Gyrs. We mainly show the results for the “standard model” (i.e., Model 1) which shows typical behaviors of gas stripping in the SMC. In the followings, the time T is measured with respect to the present-time ($T = 0$): for example, $T = -1.5$ Gyr means 1.5 Gyr ago in the present study.

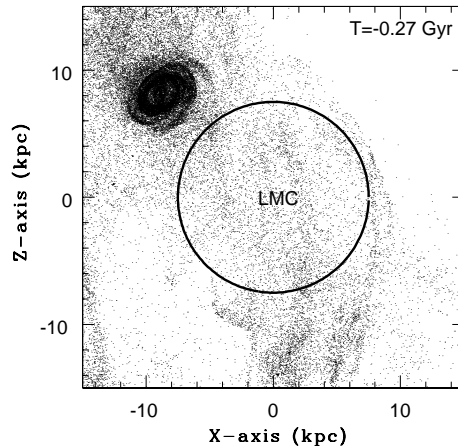


Figure 2. The distribution of gas from the SMC with respect to the LMC's center at $T = -0.27$ Gyr. The circle represents the disk radius of the LMC.

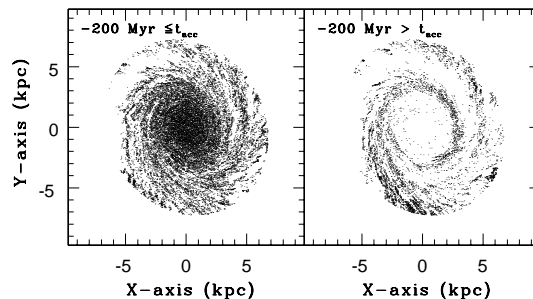


Figure 3. The initial locations (with respect to the SMC's center) of gas particles that are stripped from the SMC and then pass through the central 7.5 kpc of the LMC before (right) and after (left) $T = -200$ Myr in the standard model. t_{acc} denotes the time when a particle passes through the central region of the LMC *last time*.

3 RESULTS

Fig.1 shows, for the standard model (Model 1), the time evolution of the total gas mass (stripped from the SMC) which reaches and is just located within the central 7.5 kpc of the LMC at each time step, M_{acc} . It is noted that M_{acc} is not an accumulated gas mass but is changeable with time

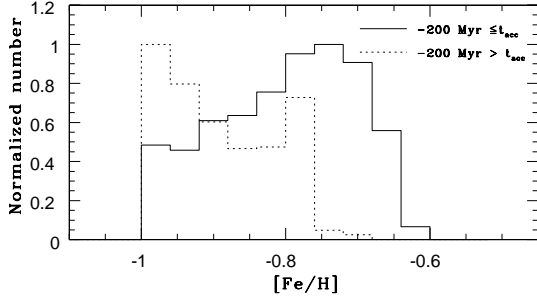


Figure 4. The metallicity distribution (MD) of gas particles with $-200 \text{ Myr} \leq t_{\text{acc}}$ (solid) and $t_{\text{acc}} < -200 \text{ Myr}$ (dotted) in the standard model. This MD depends strongly on initial metallicity gradients.

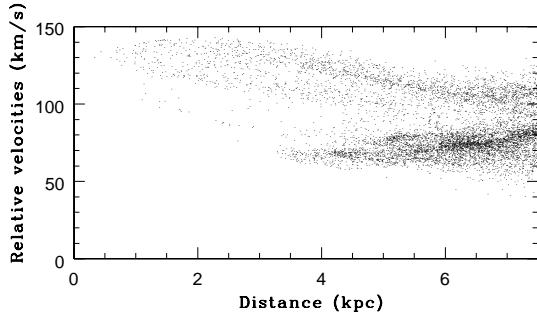


Figure 5. Plots of one-dimensional relative velocities (V_{rel}) of the SMC's gas particles as a function of their distances from the center of the LMC at $T = -200 \text{ Myr}$ in the standard model. Here V_{rel} for each particle is estimated as $V_{\text{rel}} = ((v_{\text{lx}}^2 + v_{\text{ly}}^2 + v_{\text{lz}}^2)/3)^{0.5}$, where v_{lx} , v_{ly} , and v_{lz} are X -, Y -, and Z -components of the relative velocity of the particle with respect to the LMC's velocity, respectively.

as gas particles can pass through the LMC in the current collisionless simulation. It is clear that the M_{acc} evolution shows a number of peaks with the first peak about $T = -1.3 \text{ Gyr}$ ($M_{\text{acc}} = 1.8 \times 10^6 M_{\odot}$), just after the first pericenter passage of the SMC with respect to the Galaxy in the 2.5 Gyr evolution. The highest peak is seen at $T = -200 \text{ Myr}$ ($M_{\text{acc}} = 4.9 \times 10^7 M_{\odot}$), when the LMC and the SMC interact the most strongly. Since the gas mass (M_{acc}) at its peak is not negligibly small compared with the present-day HI mass of the LMC ($7.0 \times 10^8 M_{\odot}$; v00), accretion and infall of the gas onto the LMC's gas disk can increase local gas densities and consequently can possibly trigger star formation in the LMC. Fig. 2 demonstrates the epoch of the “Magellanic squall”, when the stripped gas particles of the SMC are falling onto the disk of the LMC.

Fig. 3 shows the initial locations of the SMC's gas particles (with respect to the SMC's center) with $-200 \text{ Myr} \leq t_{\text{acc}}$ and $t_{\text{acc}} < -200 \text{ Myr}$, where t_{acc} denotes the time when a particle passed through the central region of the LMC last time. The particles with $t_{\text{acc}} < -200 \text{ Myr}$ are initially located in the outer part of the SMC so that they can be stripped from the SMC and consequently pass through the LMC earlier. Owing to the small pericenter distance of the LMC-SMC orbital evolution at $T = -200 \text{ Myr}$, the SMC is strongly disturbed to lose gas particles not only from its outer part but from its inner one. As a result of this, gas initially located throughout the gas disk of the SMC can pass

through the central region of the LMC at $T = -200 \text{ Myr}$ and thus show $-200 \text{ Myr} \leq t_{\text{acc}}$.

The abovementioned differences in the initial spatial distributions between gas particles with $-200 \text{ Myr} \leq t_{\text{acc}}$ and $t_{\text{acc}} < -200 \text{ Myr}$ can cause the differences in metallicity distributions of the gas between the two populations, because the SMC's gas disk is assumed to have a negative metallicity gradient. Fig. 4 shows that the gas particles with $t_{\text{acc}} < -200 \text{ Myr}$ have a larger fraction of metal-poor gas with $-0.6 \leq [\text{Fe}/\text{H}] \leq -1.0$ and a mean metallicity of $[\text{Fe}/\text{H}] = -0.86$. The particles with $t_{\text{acc}} \approx -1.3 \text{ Gyr}$ has a mean metallicity of $[\text{Fe}/\text{H}] = -0.95$, because they are initially located in the outermost part of the SMC's gas disk. Fig. 4 also shows that the gas particles with $-200 \text{ Myr} \leq t_{\text{acc}}$ have a peak around $[\text{Fe}/\text{H}] = -0.7$ with a mean metallicity of $[\text{Fe}/\text{H}] = -0.77$. The particles with $t_{\text{acc}} \approx -200 \text{ Myr}$ has a mean metallicity of $[\text{Fe}/\text{H}] = -0.86$. These results clearly suggest that the LMC can replenish gas supplies through accretion and infall of *metal-poor gas from the SMC* onto the LMC's disk. It should be stressed here that the metallicities of accreted gas from the SMC at $t_{\text{acc}} \approx -200 \text{ Myr}$ can be appreciably higher than the above, if we consider chemical evolution of the SMC due to star formation for the last 2.5 Gyr.

Fig. 5 shows that relative velocities (V_{rel}) of the SMC's gas particles within the central 7.5 kpc of the LMC with respect to the LMC velocity range from 40 to 150 km s^{-1} at $T = -200 \text{ Myr}$. This result indicates that if the particles can infall onto the LMC's disk, they can give strong dynamical impact on the HI gas of the LMC and possibly cause shock energy dissipation owing to V_{rel} much higher than the sound velocities of cold gas. Previous numerical simulations showed that cloud-cloud collisions with moderately high relative velocities ($V_{\text{rel}} = 10 - 60 \text{ km s}^{-1}$) can trigger the formation of SCs (Bekki et al. 2004a). Therefore the above result implies that some fraction of the particles passing through the LMC's central region can be responsible for the formation of new SCs in the LMC.

The parameter dependences of $[\text{Fe}/\text{H}]_{\text{acc}}$ and f_{acc} are briefly summarized as follows. Firstly $[\text{Fe}/\text{H}]_{\text{acc}}$ and f_{acc} do not depend so strongly on baryonic fractions, gas mass fractions, and orbital configurations (See the Table 2): $[\text{Fe}/\text{H}]_{\text{acc}}$ (f_{acc}) ranges from -0.79 (0.34) to -0.82 (0.47) for a fixed size ratio of $r_g (= R_g/R_s)$. Secondly, $[\text{Fe}/\text{H}]_{\text{acc}}$ and f_{acc} are *both larger* in the model with smaller r_g (Model 6) for which a smaller amount of gas particles can be tidally stripped from the SMC. The reason for the larger f_{acc} is that a significantly larger fraction of particles once stripped from the SMC can pass through the LMC in Model 6. Thirdly, the morphological type of the SMC in the present study is not important for $[\text{Fe}/\text{H}]_{\text{acc}}$ and f_{acc} . Given the fact that only 0.2% of gas can be converted into strongly bound SCs (rather than into field stars) in the evolution of the MCs (B05), these results imply that the maximum possible mass of SCs formed from SMC's gas in the LMC is roughly $10^5 M_{\odot}$ in the present models. Owing to the very short time scale ($\sim 10^6 \text{ yr}$) of SC formation from gas clouds during the tidal interaction (Bekki et al. 2004b), the stripped SMC's gas clouds are highly likely to be accreted onto the LMC within the dynamical time scale of the LMC ($\sim 10^8 \text{ yr}$) and then converted into SCs within $\sim 10^6 \text{ yr}$ after the accretion.

4 DISCUSSIONS AND CONCLUSIONS

NGC 1718 with an estimated age of ~ 2 Gyr has a low metallicity ($[\text{Fe}/\text{H}] \sim -0.8$) about 0.3 dex smaller than those of other SCs with similar ages in the LMC (e.g., G03; G06). If the interstellar medium (ISM) of the LMC about 1 – 2 Gyr ago was very inhomogeneous in terms of chemical abundances, some fraction of stars could be born from quite low-metallicity gas clouds with $[\text{Fe}/\text{H}] \sim -0.8$. The distinctively low metallicity therefore could be due to the abundance inhomogeneity of the ISM in the LMC about 1 – 2 Gyr ago. However, intermediate-age SCs *other than* NGC 1718 have very similar metallicities of $[\text{Fe}/\text{H}] \sim -0.48$ and a small metallicity dispersion of only 0.09 dex in the LMC (G06). The observed low-metallicity of NGC 1718 thus seems to be unlikely to be due to the abundance inhomogeneity of the ISM. We suggest that the origin of the NGC 1718 can be closely associated with the Magellanic squall about 1 – 2 Gyr ago. Since gaseous abundance patterns (e.g., $[\text{Mg}/\text{Fe}]$) of the SMC about a few Gyr ago might well be very different from those of the LMC, NGC 1718 could have abundance patterns quite different from those of other GCs. It should be here stressed that the simulated peak of the squall (~ 1.3 Gyr) is not very consistent with the observed age of NGC 1718 (2.0 ± 0.4 Gyr, G03).

S04 recently have reported that eight young SCs with ages less than 200 Myr have metallicities smaller than $[\text{Fe}/\text{H}] = -0.3$ that is a typical stellar metallicity of the LMC (e.g., v00). Although there could be some observational uncertainties in age and metallicity determination based solely on integrated spectrophotometric properties of SCs (S04), their results imply that these SCs could have been formed from metal-poor gas in the LMC quite recently. The present numerical results imply that NGC 1711, NGC 1831, NGC 1866, and NGC 1984, all of which are observed to have possible metallicities smaller than $[\text{Fe}/\text{H}] = -0.6$, can be formed as a result of the Magellanic squall. Since the chemical abundances of the outer gas disk of the SMC can be significantly different from those of the present LMC's gas disk, the detailed abundances (e.g., $[\text{C}/\text{Fe}]$, $[\text{N}/\text{Fe}]$, and $[\text{Mg}/\text{Fe}]$) of the above four clusters can be significantly different from those of other young SCs with “normal” metallicities with $[\text{Fe}/\text{H}] = -0.3 - -0.5$ in the LMC. The observed young, metal-poor stars ($[\text{Fe}/\text{H}] \sim -1.0$) in the inter-Cloud region close to the LMC (R99) will be equally explained by the gas-transfer between the MCs (see also Bekki & Chiba 2007).

The present study has first pointed out that the Magellanic squall can also play a role in the relatively recent star formation history of the LMC. Sporadic infall of metal-poor gas like the Magellanic squall might well be also important for recent star formation histories in pairs of interacting galaxies. Previous hydrodynamical simulations showed that high-velocity collisions of HI gas onto a galactic disk can create HI holes and shells (e.g., Tenorio-Tagle et al. 1986). The Magellanic squall, which inevitably can cause high-velocity impact of the gas clouds stripped from the SMC on the LMC, can thus be responsible for *some* of the observed HI holes in the LMC (e.g., Staveley-Smith et al. 2003). We plan to investigate how collisions between low-metallicity gas clouds from the SMC and those initially in the LMC trigger the formation of stars and SCs in the LMC's disk based on more sophisticated, high-resolution hydrodynamical

simulations with pc-scale star formation processes. Our future studies thus will enable us to understand more deeply how the Magellanic squall influences pc-scale star formation processes in the LMC.

5 ACKNOWLEDGMENT

We are grateful to the referee, Daisuke Kawata, for his valuable comments, which contribute to improve the present paper. K.B. acknowledges the Large Australian Research Council (ARC). Numerical computations reported here were carried out on GRAPE system kindly made available by the Astronomical Data Analysis Center (ADAC) of the National Astronomical Observatory of Japan.

REFERENCES

- Bekki, K., Chiba, M. 2005, MNRAS, 356, 680 (B05)
- Bekki, K., Chiba, M. 2007, PASA, 24, 21
- Bekki, K., Beasley, M. A., Forbes, D. A., Couch, W. J. 2004a, ApJ, 602, 730
- Bekki, K., Couch, W. J., Beasley, M. A., Forbes, D. A., Chiba, M., Da Costa, G. 2004b, 610, L93
- Cole, A. A., Tolstoy, E., Gallagher, J. S. III., Smecker-Hane, T. A. 2005, AJ, 129, 1465
- Connors, T. W., Kawata, D., Gibson, B. K. 2006, MNRAS, 371, 108
- de Blok, W. J. G., Walter, F. 2003, MNRAS, 341, L39
- Gardiner, L. T. Noguchi, M. 1996, MNRAS, 278, 191 (G96)
- Geisler, D., Piatti, A. E., Bica, E., Clariá, J. J. 2003, MNRAS, 341, 771 (G03)
- Grocholski, A. J., Cole, A. A., Sarajedini, A., Geisler, D., Smith, V. V. 2006, AJ, 132, 1630 (G06)
- Harris, J., Zaritsky, D. 2006, AJ, 131, 2514
- Kallivayalil, N., van der Marel, R. P., Alcock, C. 2006, ApJ, 652, 1213
- Murai, T. Fujimoto, M. 1980, PASJ, 32, 581
- Navarro, J. F., Frenk, C. S., White, S. D. M. 1996, ApJ, 462, 563
- Piatti, A. E., Sarajedini, A., Geisler, D., Clark, D., Seguel, J. 2007, MNRAS, 377, 300
- Rolleston, W. R. J., Dufton, P. L., McErlean, N. D., Venn, K. A. 1999, A&A, 348, 728 (R99)
- Santos, J. F. C., Jr., Piatti, A. E. 2004, A&A, 428, 79 (S04)
- Staveley-Smith, L., Kim, S., Calabretta, M. R., Haynes, R. F., Kesteven, M. J. 2003, MNRAS, 339, 87
- Sugimoto, D., Chikada, Y., Makino, J., Ito, T., Ebisuzaki, T., Umemura, M. 1990, Nature, 345, 33
- Tenorio-Tagle, G., Bodenheimer, P., Rozyczka, M., Franco, J. 1986, A&A, 170, 107
- van den Bergh, S. 2000, The Galaxies of the Local Group, Cambridge: Cambridge Univ. Press. (v00)
- Westerlund, B. E. 1997, The Magellanic Clouds, Cambridge: Cambridge Univ. Press
- Zaritsky, D., Kennicutt, R. C., Jr., Huchra, J. P. 1994, ApJ, 420, 87